NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL
COMMISSION ON PHYSICAL SCIENCES, MATHEMATICS, AND APPLICATIONS
Board on Physics and Astronomy
Solid State Sciences Committee

Final Progress Report
for the period
4/1/92 through 3/31/95
to the
Department of Energy
on the

Solid State Sciences Committee

Contract No. DE-FG05-92ER45469

This final technical progress report reviews the activities of the Solid State Sciences Committee (SSSC) for the period April 1, 1992, through March 31, 1995.

THE SOLID STATE SCIENCES COMMITTEE

The Solid State Sciences Committee is a standing committee under the auspices of the Board on Physics and Astronomy, Commission on Physical Sciences, Mathematics, and Applications of the National Academy of Sciences—National Research Council. The SSSC is a multidisciplinary committee with membership drawn from universities, industry, government, and national laboratories. Its members' areas of expertise include condensed matter physics, solid state chemistry, and materials research aspects of ceramics, electronic materials, metallurgy, and polymers. The Committee is broadly representative of the community, providing perspective on issues that affect the progress and vitality of the materials sciences. A special effort has been made to ensure that the committee takes into account the roles in the field of both the science and engineering communities.

The SSSC identifies and makes recommendations on issues of concern to the materials research, development, and applications community, particularly in connection with research opportunities, and provides guidance to federal agencies regarding their materials sciences research programs. Since its organization in 1971, the Committee's operating guidelines have included the following objectives: (1) to respond to requests for technical advice and assistance from federal agencies; (2) to initiate and oversee the conduct and publication of studies in the solid state sciences and its strong multidisciplinary connections to other fields of science and technology; (3) to act as an educational resource for the community of solid state scientists and materials scientists in the United States by identifying critical scientific issues and opportunities; and (4) to provide a forum for discussion among solid state and materials scientists and Washington policy makers. Several mechanisms are used to achieve these objectives. The Committee organizes and conducts special technical studies, surveys, workshops, and other meetings. It also functions as an oversight committee for ad hoc panels charged with the task of preparing reports on specific issues or topics. Symposia held at the National Academy of Sciences or at research centers have been used to focus attention on particular issues connected with facilities, programs, or other matters of concern to the community.

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The work that the SSSC has conducted since its inception leaves it well prepared to respond to requests for studies on a broad array of topics and issues. Specific report-generating projects are proposed and funded separately, as the committee identifies key issues itself or accepts requests from government agencies.

SSSC ACTIVITIES DURING THIS REPORTING PERIOD

The Solid State Sciences Committee is charged with monitoring the health of the field of materials research in the United States. Accordingly, the Committee identifies and examines both broad and specific issues affecting the field. Among the mechanisms it uses to fulfill its charge are regular meetings, teleconferences, briefings from agency representatives and the scientific community, special forums, and the formation of study panels to prepare reports.

Over the last few years the SSSC has tracked, and when requested participated in, the development of a Federal initiative on advanced materials and processing. The Federal Advanced Materials and Processing Program (AMPP) was the topic of the 1993 SSSC Forum, which the Committee cosponsored with the National Materials Advisory Board and the Washington Materials Forum. The proceedings were prepared for publication during the reporting period, and the 1991 Forum Proceedings, which also focused on the AMPP, were published as well.

The 1996 forum will have the tentative title *The Role of Condensed Matter Science in Future Technology*. Among its other functions it will serve to kick off a planned SSSC study assessing the status of condensed matter science. During the reporting period, the Committee worked on planning both the 1996 forum and the assessment of condensed matter science.

In keeping with its charge to identify and highlight areas where there are scientific and technological opportunities, the SSSC has continued to oversee studies on specific technical topics. A study of free-electron lasers and other advanced light sources, performed in cooperation with the NRC's Board on Chemical Sciences and Technology, was published in August, 1994. A study on biomolecular materials made considerable progress during the reporting period and should be completed soon. A major study of optical science and engineering held its first meeting in March, 1995.

HIGHLIGHTS OF SSSC MEETINGS DURING THIS REPORTING PERIOD

Regular meetings of the SSSC and special meetings with agency representatives and the scientific community are essential to the Committee's function. This section presents the highlights of meetings held during the reporting period.

October 26, 1992 (Washington, DC). The fall 1992 meeting of the SSSC focused on several areas. Charles Shank, new SSSC member, talked about the changing role of the National Labs. John Rush, Paul Fleury, and Julia Weertman reviewed the preliminary recommendations of the Basic Energy Sciences Advisory Committee (BESAC) Panel on Neutron Science and the Townes Committee response to this interim report. The impact of this activity on the planned SSSC study on neutron science was discussed. Pierre Hohenberg led an open discussion on the changing role of the National Science Foundation. There was a lengthy discussion involving committee members and the John Hopps, new Director of the NSF Materials Science Division. Jerry Smith reviewed the DOE Materials Research Program. Finally, the Committee received status reports on its activities and considered future plans.

In addition to the above regular meeting, representatives of the SSSC participated in several teleconferences over the past few months to review the status of the proposed study on neutron scattering science that has been requested by the Department of Energy (DOE), and to plan the 1993 SSSC Forum.

April 25-26, 1992 (Washington, DC). Committee members are often requested to brief agency representatives, the scientific community, or other groups on matters of importance to the solid state and materials sciences community-at-large. The SSSC Chair attended the April 1992 meeting of the BPA in order to review the activities of SSSC and its panels.

May 4, 1993 (Washington, DC). The SSSC met briefly after the 1993 Forum to discuss the Forum, plan the follow-up, and consult with William Harris, Assistant Director, Mathematical and Physical Sciences. There was a general consensus that the 1993 Forum program set a new standard of quality and depth of coverage. Plans were developed to hold the next meeting of the committee at Lawrence Berkeley Laboratory.

October 12-13, 1993 (Berkeley, CA). The fall 1993 meeting of the SSSC, held at the Lawrence Berkeley Laboratory, focused on several areas. The progress of the Panel on Biomolecular Materials was discussed. The panel chair is working to synthesize the contributions of the various panel members. The panel's objective is to give a coherent picture of this field. The results of a program initiation meeting on information technology were discussed. Richard Howard of AT&T participated via a video conference. A representative of the Computer Science and Technology Board also participated. Developing a project in this area has been put on hold. Although there are many interesting developments in device physics, the tremendous commercial investment that is going into pushing silicon technology forward seems likely to continue to outpace the development of any potential leapfrog technology. Progress in the foreseeable future will probably come from continued development of silicon manufacturing technology combined with innovations in microprocessor architecture. The endpoint of present VLSI technology is nowhere in sight. A new project being carried out jointly with the Board on Chemical Sciences and Technology entitled Free Electron Lasers and Other Advanced Coherent Light Sources was discussed. The project was still in the planning stage at the time of the meeting. The charge to the FEL panel will be to assess the scientific progress that might be achieved with a new generation of free electron lasers. A proposed major new study on optical science and engineering was discussed by Elsa Garmire. This study will cover the range from basic science to applications in manufacturing of optical science. OSE is a key enabling technology with applications in manufacturing, information technology, health, transportation, and environmental assessment and research. Optical science also contains a number of frontier areas of research. The Committee then turned to a wide-ranging discussion of The Changing Environment for Solid State Sciences and Materials Science and Engineering. Perspectives from the universities, from business and industry, and from government laboratories were considered. The NRC Office of Scientific and Engineering Personnel presented statistics on the changing manpower situation in science. Changing curricula in MSE were discussed. Paul Fleury made a presentation on the applications of basic science and instrumentation to problems in processing technology. The Committee decided to make this topic the theme of the 1995 Forum. After an introduction by Chuck Shank, LBL staff scientists made presentations on various topics, including their molecular design initiative, SQUIDS in the submicron regime, tunneling microscopy, electron transfer in nanostructures, and an introduction to the Advanced Light Source sited at LBL.

June 19-20, 1994 (Washington, DC). The Spring 1994 meeting was devoted to planning for the future and consulting with agency leaders. The Committee resolved to go forward with plans for a new assessment of condensed-matter science. Paul Fleury and Julia Weertman were charged with preparing a draft plan for distribution to the Committee. (The NRC's Governing Board has since approved undertaking this project and funding proposals are being prepared.) There were also discussions of the next SSSC Forum, focussing on processing science and manufacturing. The Committee reviewed the status of the studies of free electron lasers and optical science and engineering, and considered ways to provide useful input to these activities. Paul Percy of Sandia made a presentation on the Semiconductor Industry Association Roadmap. He emphasized the relative predictability of progress in integrated

circuit design and manufacturing, which makes it possible to prepare a credible roadmap for the next several years of the development of the field. The status of neutron science was reviewed, including the need for the Advanced Neutron Source. The members of the committee asked the chair to prepare a letter of endorsement for moving forward with the ANS. (The full membership of the SSSC subsequently approved this letter.) John Joannopoulos of MIT made a presentation on photonic band-gap materials. The second day of the meeting was devoted to discussions with agency leaders, including Arati Prabhakar, Director of NIST; William Harris, Assistant Director of NSF; and Robert Gottschall, Director of Materials Science at DOE/Energy Research.

November 13, 1994 (Washington, DC). Much of the Fall 1994 meeting was devoted to a wide-ranging discussion of plans for the 1995 Forum. A major topic of discussion was how recent changes in the Congress should affect the selection of speakers and the choice of subjects for the sessions. (The Committee has since decided to broaden the topic of the Forum to address the role of condensed matter science in future technology.) A small group of Committee members agreed to get together informally to work on Forum planning. The Committee also discussed plans for other future projects, including the new assessment of condensed matter science, and a variety of ideas for new research briefings and studies. James Roberto reviewed the conclusions of the now-completed study of free electron lasers, and led a discussion of the prospects for the Advanced Neutron Source. Charles Shank summarized the status of the new study of optical science and engineering, of which he was recently appointed chair. Bob Richardson led a discussion of concerns about materials science funding at the DOE Office of Basic Energy Sciences. David Wilkinson (Princeton) gave a talk about physics education, both undergraduate and graduate, in U.S. universities. He highlighted some of the current problems, discussed recent proposals for improvement, and showed a video of undergraduates in a recently revamped lab course for non-physics majors.

STATUS OF SSSC PROJECTS

During this reporting period, the SSSC was involved with 4 major projects: the study of optical science and engineering, the biomolecular materials study, the 1993 forum, and the study of free-electron lasers.

Optical Science and Engineering

The committee's parent Board on Physics and Astronomy and the National Materials Advisory Board are cooperating on a major study of optical science and engineering. The SSSC is monitoring and assisting this study because many of the scientific areas that it will address, such as photonics and optical materials, lie within the SSSC's purview. The study committee was appointed during the reporting period. It is chaired by Charles Shank, director of Lawrence Berkeley Laboratory and a member of the SSSC. The members are drawn from a wide range of backgrounds in optical science and engineering, including representatives of universities, government laboratories, and small and large businesses. The committee held its organizational meeting in March, 1995, at which it established small working groups to begin planning a series of workshops to develop information for the report.

Biomolecular Materials

A study of the scientific potential and research status of self-assembling and biomolecular materials is being conducted under the SSSC's auspices by the Panel on Biomolecular Materials. The panel is chaired by Philip Pincus (University of California at Santa Barbara) and has a total of 12 members, with expertise in such areas as solid state physics, chemical physics, organic chemistry, physical chemistry, polymer chemistry, materials science and engineering, biomolecular engineering, molecular biology,

biochemistry, and biophysics. [See attached roster.] A complete draft of the panel's report is nearly ready to begin the NRC's peer review process. The final report should be published later this year.

As the oversight committee for the Panel on Biomolecular Materials, the SSSC continued to assist the Panel in addressing its charge. David Litster, SSSC Past Chair, has been an active participant in the project. Following completion of the study, the SSSC will actively promote and disseminate its results.

1993 SSSC Forum

As part of its charter to provide continuing focus on issues of concern to both the materials science community and policy makers, the SSSC has sponsored and cosponsored periodic forums for over a decade. The forum process is designed to bring together the scientific community and policymakers in Washington. At each forum, policy makers are asked to address a general theme and to respond to comments and questions from the audience. There is also usually a scientific or technical theme on which talks are presented. Invitees to the forums include Washington policymakers, leaders of the materials research community, past and current members of the Board on Physics and Astronomy and its committees and panels, members of the National Materials Advisory Board, heads of university materials science and engineering departments, and liaisons from materials-related professional societies.

The 1993 SSSC Forum was held May 4-5, 1993. Its main purpose was to highlight the multiagency Advanced Materials and Processing Program (AMPP) developed by the Office of Science and Technology Policy. A keynote address was given by Senator Jeff Bingaman (D-NM). Other speakers included representatives of the federal agencies, national laboratories, universities, major companies in materials-related industries, and industry consortia.

The proceedings of this forum were prepared during the reporting period. They have completed the NRC's peer review process and will be published in the next month or two.

Free Electron Lasers and Other Advanced Coherent Light Sources

The SSSC participated in a study of free-electron lasers and other advanced coherent light sources. This project was carried out jointly with the Board on Chemical Sciences and Technology. Several members of the SSSC were appointed to the study panel, which was chaired by Prof. Donald Levy of the University of Chicago. The charge was to assess the scientific progress that might be achieved with a new generation of free electron lasers. The panel explored how FELs' ability to achieve very high intensities, variable wavelengths, and coherence could play a role in advancing various areas of science, including chemistry, condensed-matter physics, materials science, biology, and medicine. The report was published in August, 1994. Its main recommendation was that "a far-infrared free electron laser user facility capable of producing picosecond pulses should be established." Recommendations were also made for the rest of the spectrum down to 1 Å.

CONTINUING ACTIVITIES OF THE SSSC

It is the intention of the SSSC to continue to monitor developments in the materials and solid state sciences fields, and to respond effectively to inquiries from federal agencies. The SSSC will complete its present projects and undertake new ones as the need arises. The committee plans to keep meeting at least twice a year, and hold additional meetings as needed. Generally, one regular meeting per year and all symposia are held in Washington, DC to facilitate attendance by representatives of the federal agencies, liaison representatives from materials and solid state science-related professional societies, and other interested members of the science policy community. Occasionally the committee will meet at the site of a major materials-related conference to save on travel time and expenses. The SSSC will also continue to make its expertise available to federal agencies in an advisory capacity in the event that scientific input

is needed to resolve problems that arise. Ongoing activities also include a major effort in preparation of a forum on processing and manufacturing science. The SSSC will plan to hold the next Forum in 1996.

Attachment:

Roster of the Solid State Sciences Committee

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